

Tissue Ablating Apparatus and Method of Ablating TissueBACKGROUND TO THE INVENTIONFIELD OF THE INVENTION

5 The present invention relates to an apparatus and method for ablating tissue with microwave radiation. In this specification microwave means the frequency range from 5GHz to 60GHz inclusive. Preferably 14-15GHz is used for tissue ablation but the present invention is not
10 limited to this narrower range.

SUMMARY OF THE PRIOR ART

 Traditional methods of treating cancer involve removing the cancerous tissue by cutting it out
15 mechanically and/or chemotherapy, usually followed by radiotherapy. Both methods have significant drawbacks and may cause serious trauma to the patient.

 The application of heat energy to biological tissue
20 is an effective method of killing cells. Thus the present invention proposes applying microwaves to heat and thus ablate (destroy) biological tissue. This presents an interesting opportunity for the treatment of cancer as the cancerous tissue can be ablated in this way. There is
25 a need for a suitable apparatus and method for ablating tissue with microwaves for the treatment of cancer or other conditions.

SUMMARY OF THE INVENTION

30 Accordingly a first aspect of the present invention may provide a tissue ablation apparatus comprising:

 a source of microwave radiation;

the direction of the axis of said probe of $\lambda/4$ or odd multiples thereof.

5 31. A method of making a balun for a coaxial tissue ablation probe comprising the steps of spraying or otherwise placing a liquid or powder dielectric onto an outer surface of an outer conducting sheath of a coaxial probe, and if said dielectric is liquid allowing the liquid to solidify, to form the balun.

10

32. A method according to claim 31 comprising the further step of and placing an outer conductor around said dielectric.

15

33. A method according to claim 32 wherein said probe is designed for use with a microwave radiation of wavelength λ and the balun has a length in the direction of the axis of said probe of $\lambda/4$ or odd multiples thereof.

20

34. A surgical apparatus comprising:

a source of microwave radiation of a first frequency suitable for ablating tissue;

25

a probe for directing microwave radiation from the source into tissue to be ablated;

a modulator having an OFF state in which it does not modulate said microwave radiation from the source and an ON state in which it modulates microwave radiation from the source in pulses having a second frequency less than said first frequency; said second frequency being suitable for cutting tissue.

30

35. An apparatus according to claim 29 wherein the apparatus further comprises a low pass filter between said modulator and said probe; said low pass filter
5 having a first state in which it lets said first frequency pass and a second state in which it passes said second frequency, but filters out said first frequency.

36. An apparatus according to claim 34 wherein said
10 modulator is capable of varying said second frequency.

37. An apparatus according to claim 36 wherein said modulator is capable of varying said second frequency and said low pass filter is capable of varying its pass band
15 in its second state.

38. An apparatus according to any one of claims 34 to 37 wherein said first frequency is 5GHz or higher.

20 39. An apparatus according to any one of claim 34 to 38 wherein said second frequency is a frequency in the range 10kHz to 500MHz.

1/14

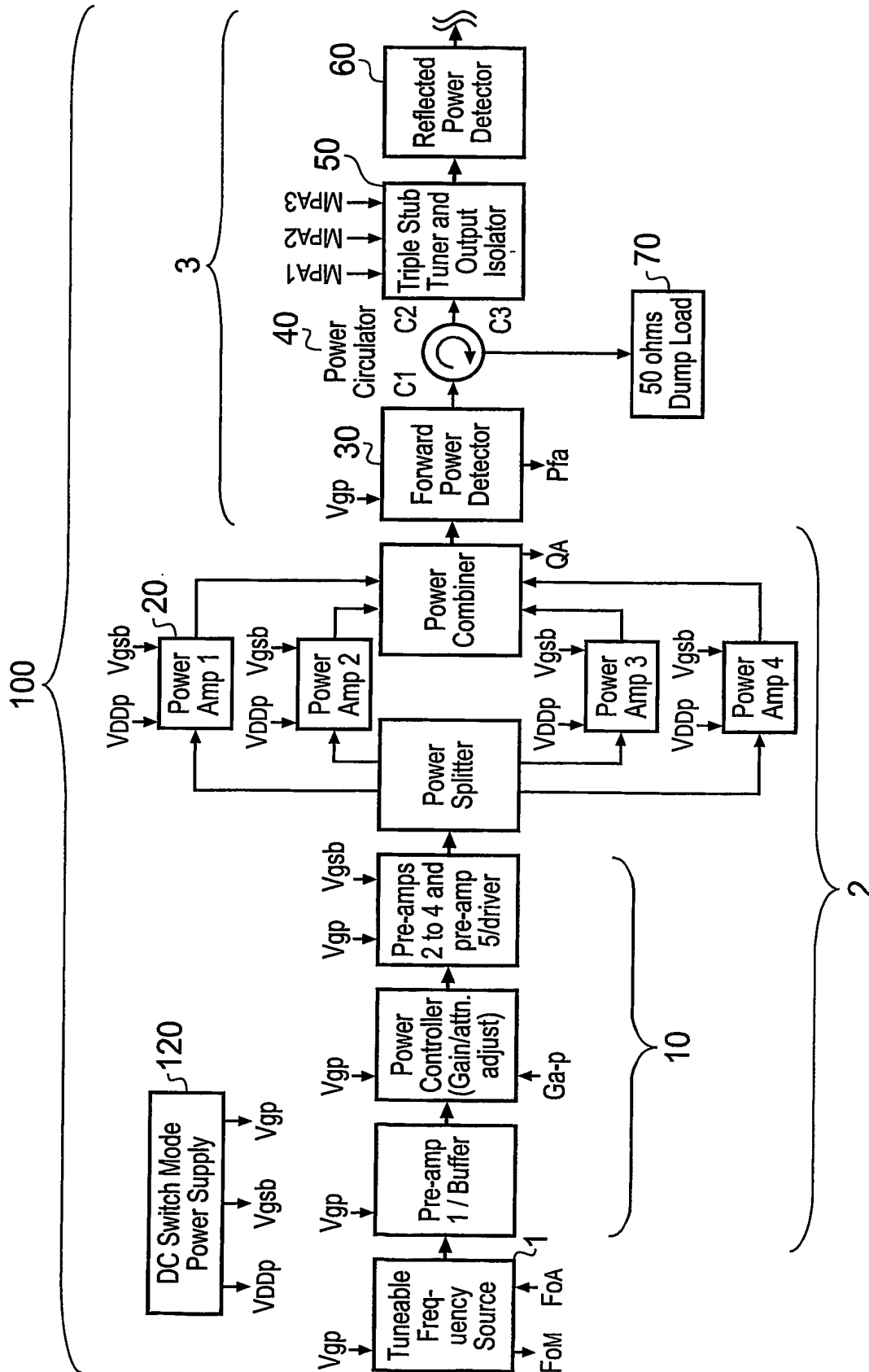


Fig. 1 (continued on page 2/14)

2/14

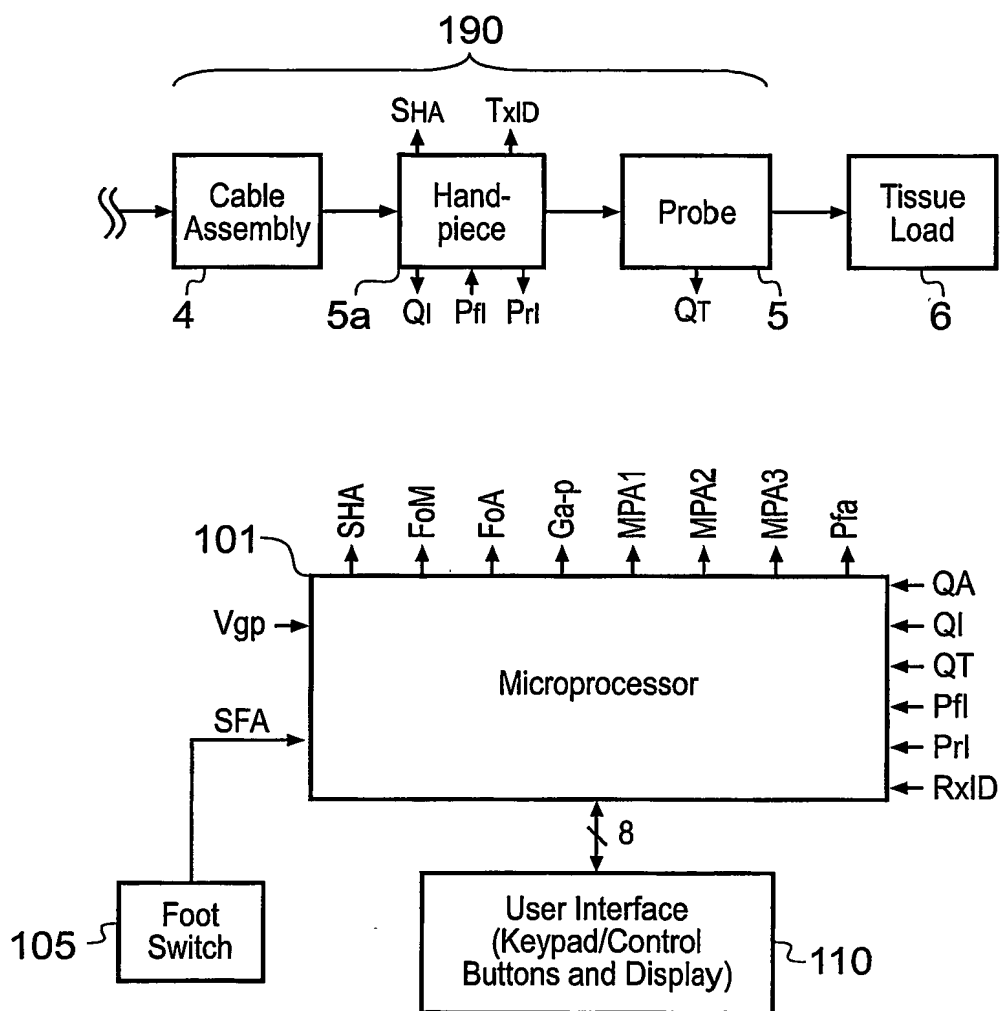


Fig. 1 (continued from page 1/14)

3/14

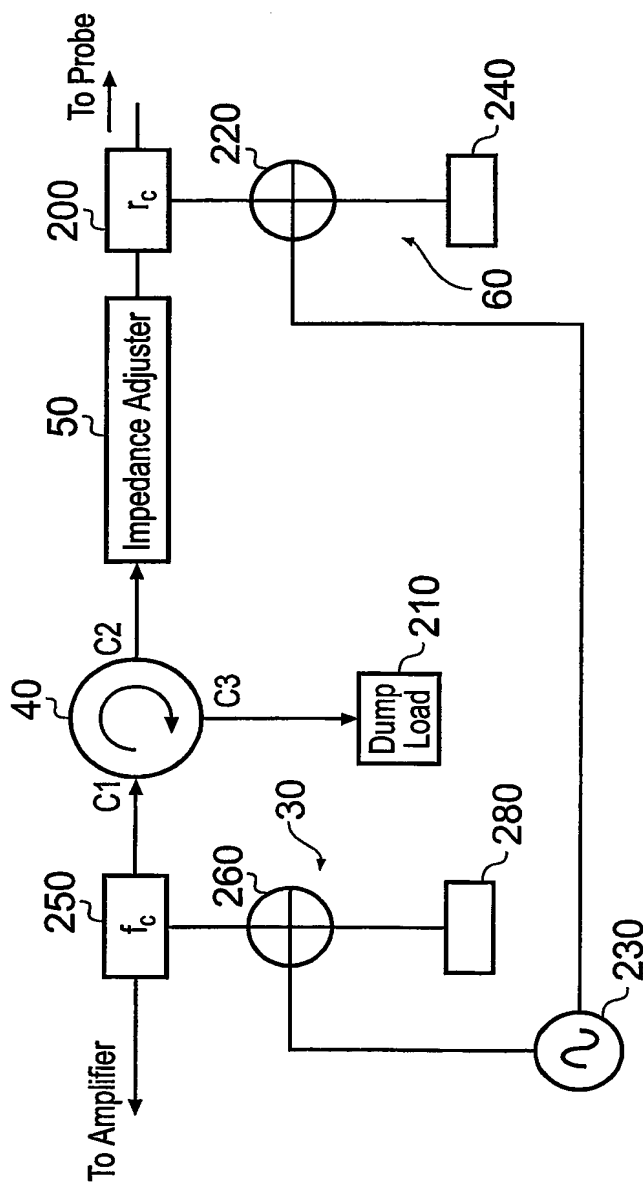


Fig. 2

4/14

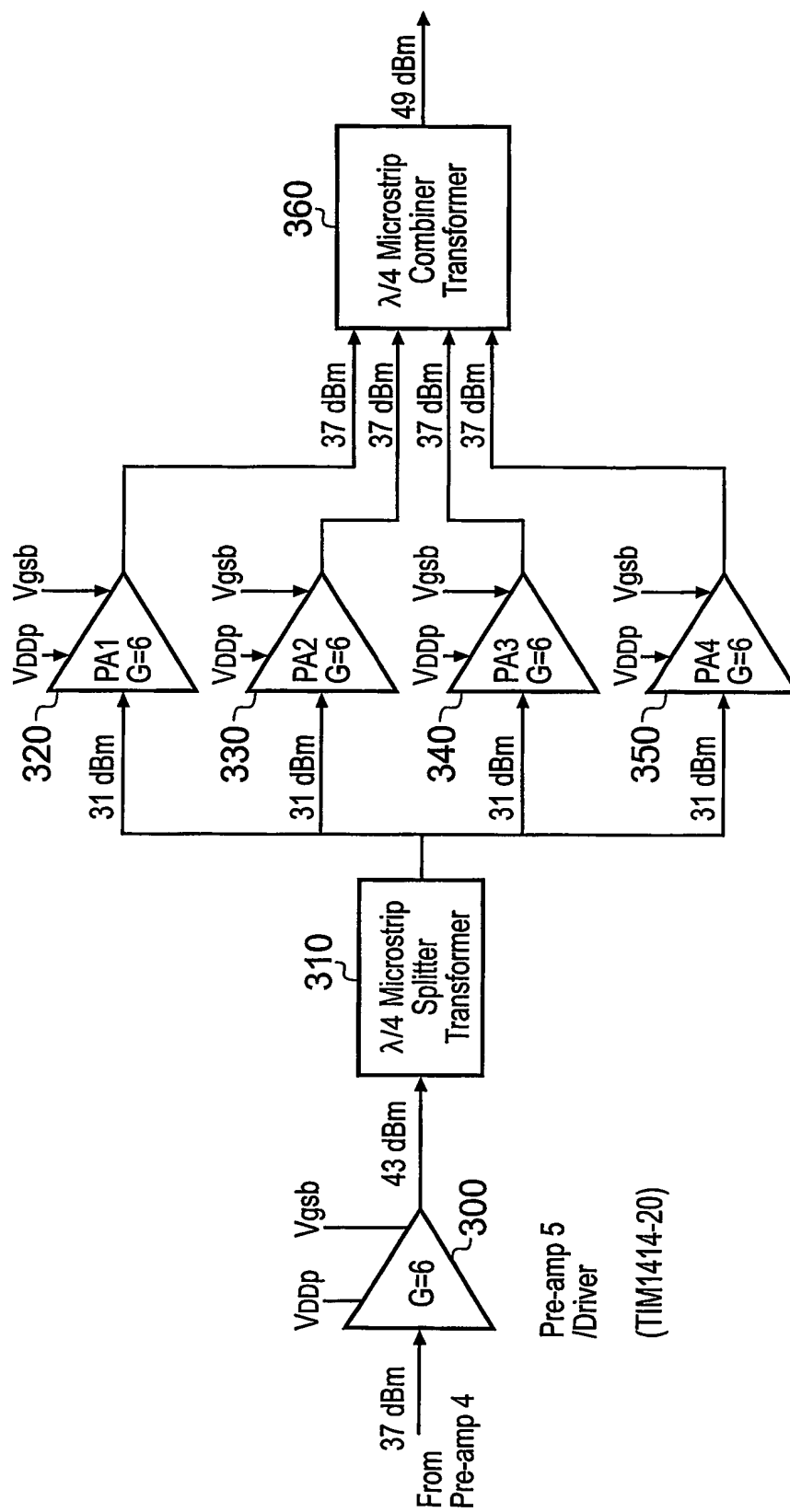


Fig. 3

5/14

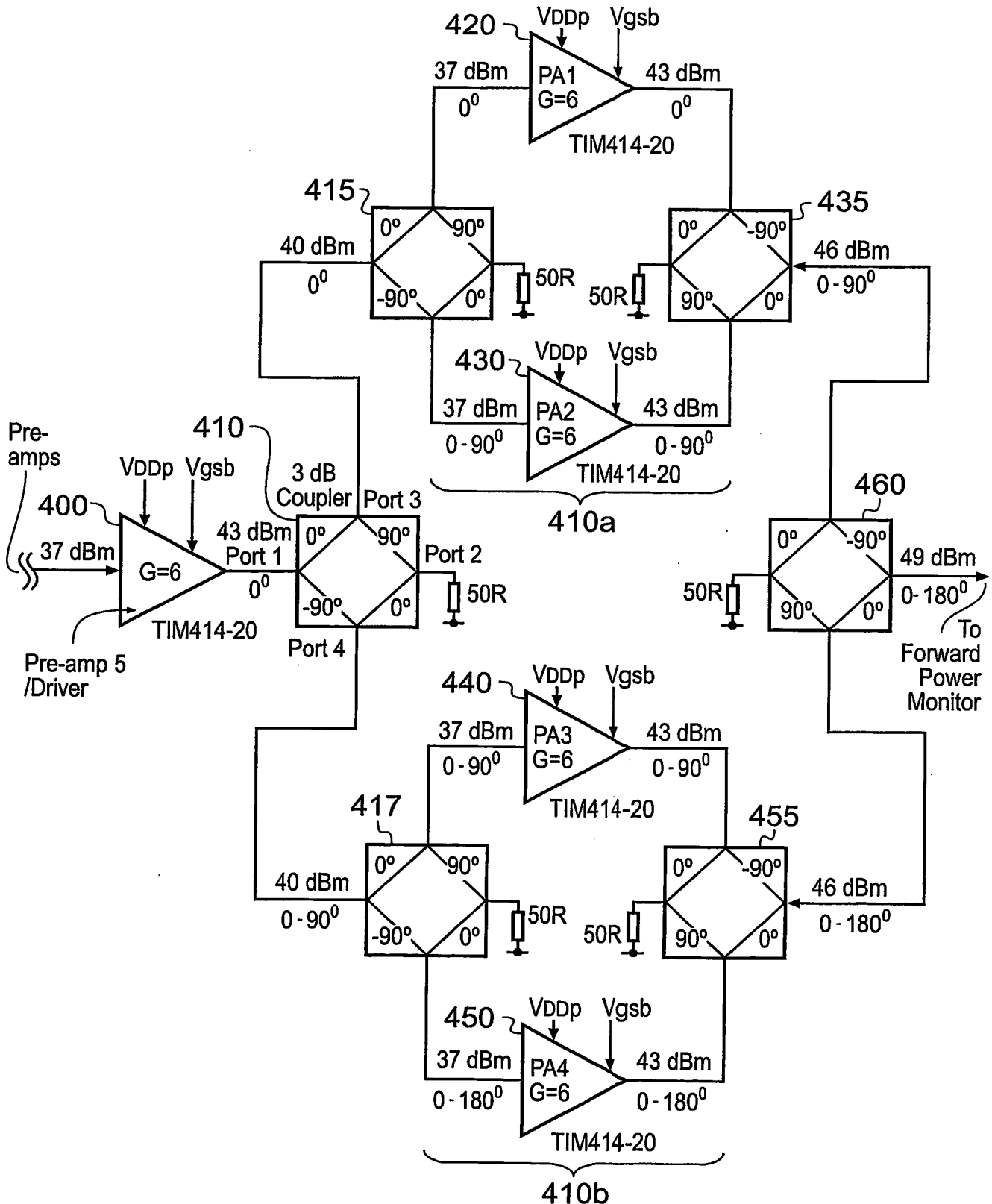


Fig. 4

6/14

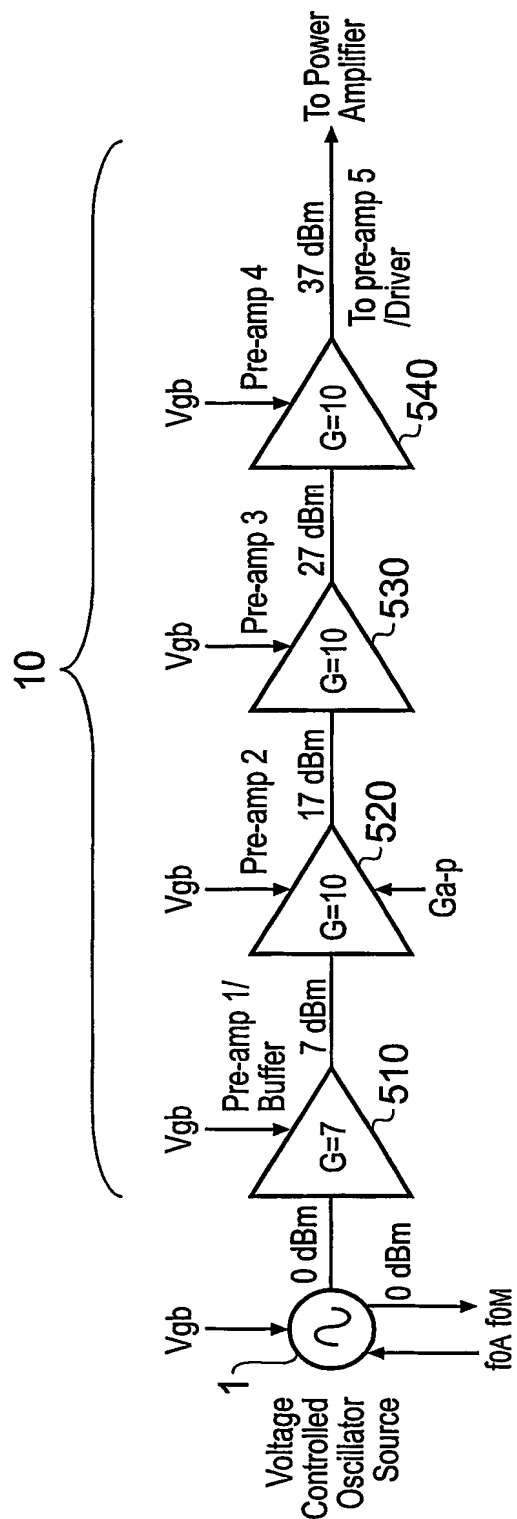


Fig. 5

7/14

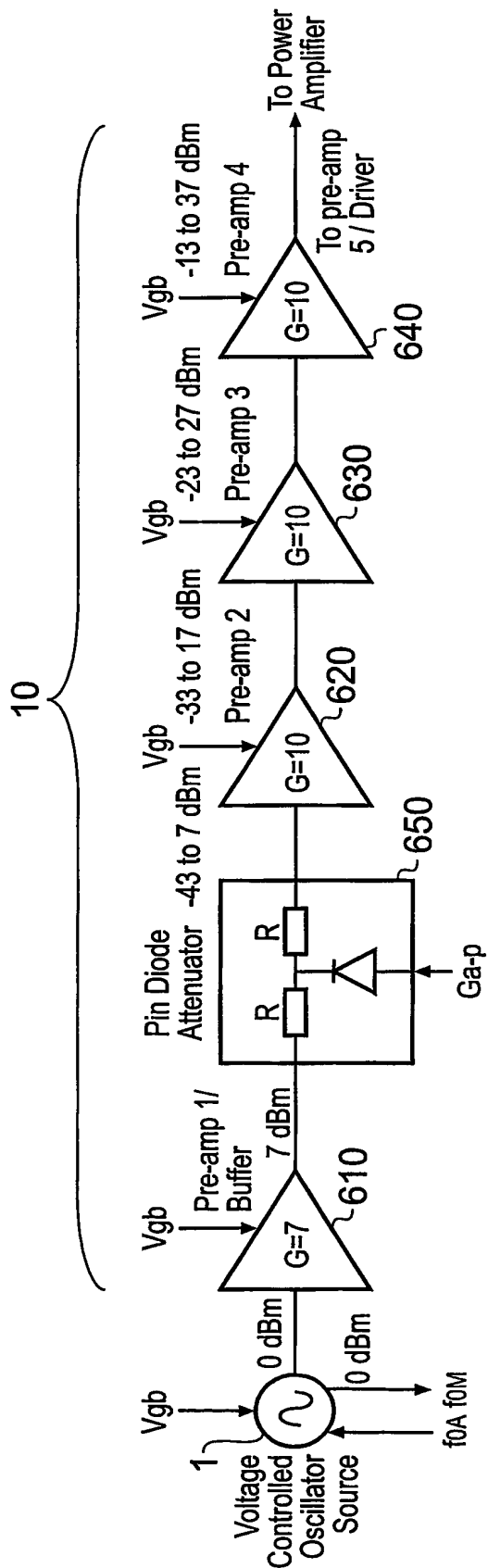


Fig. 6

8/14

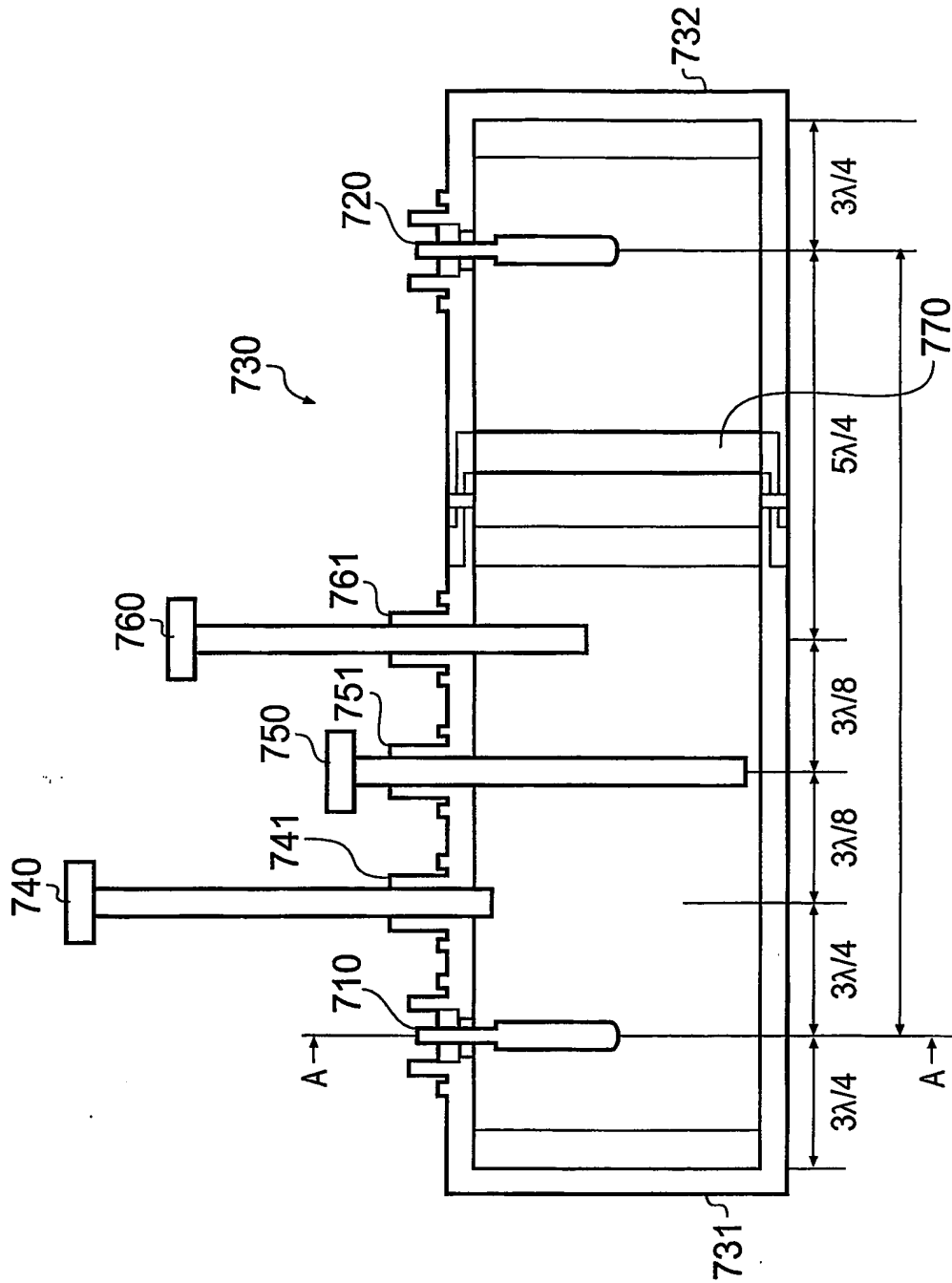
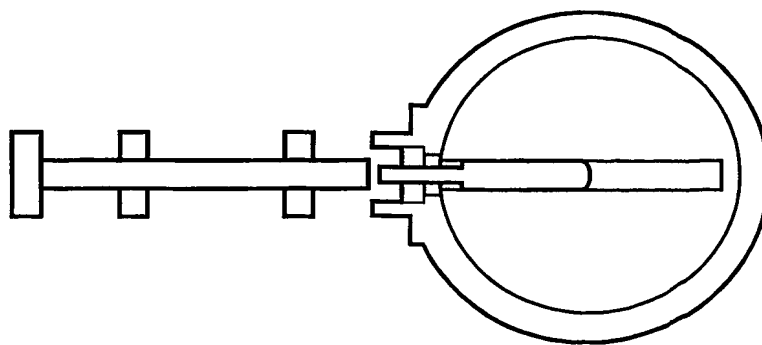


Fig. 7



Section A - A

Fig. 8

9/14

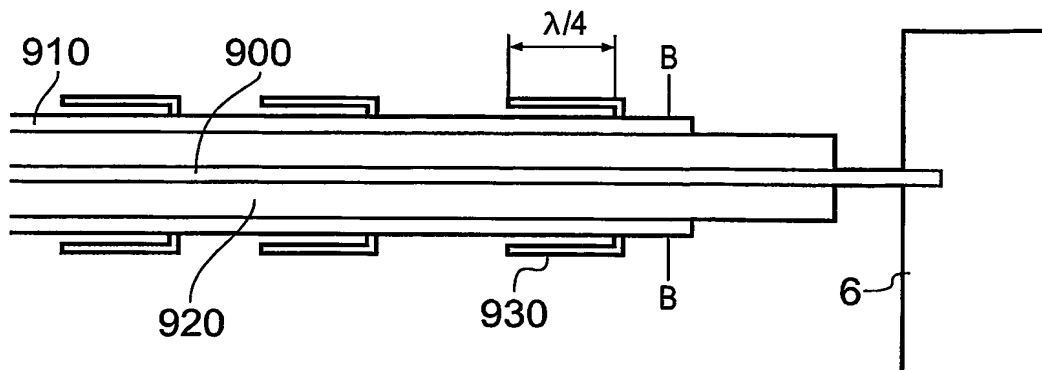


Fig. 9

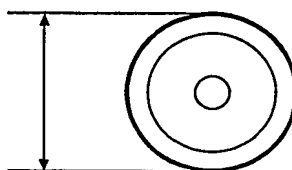


Fig. 10

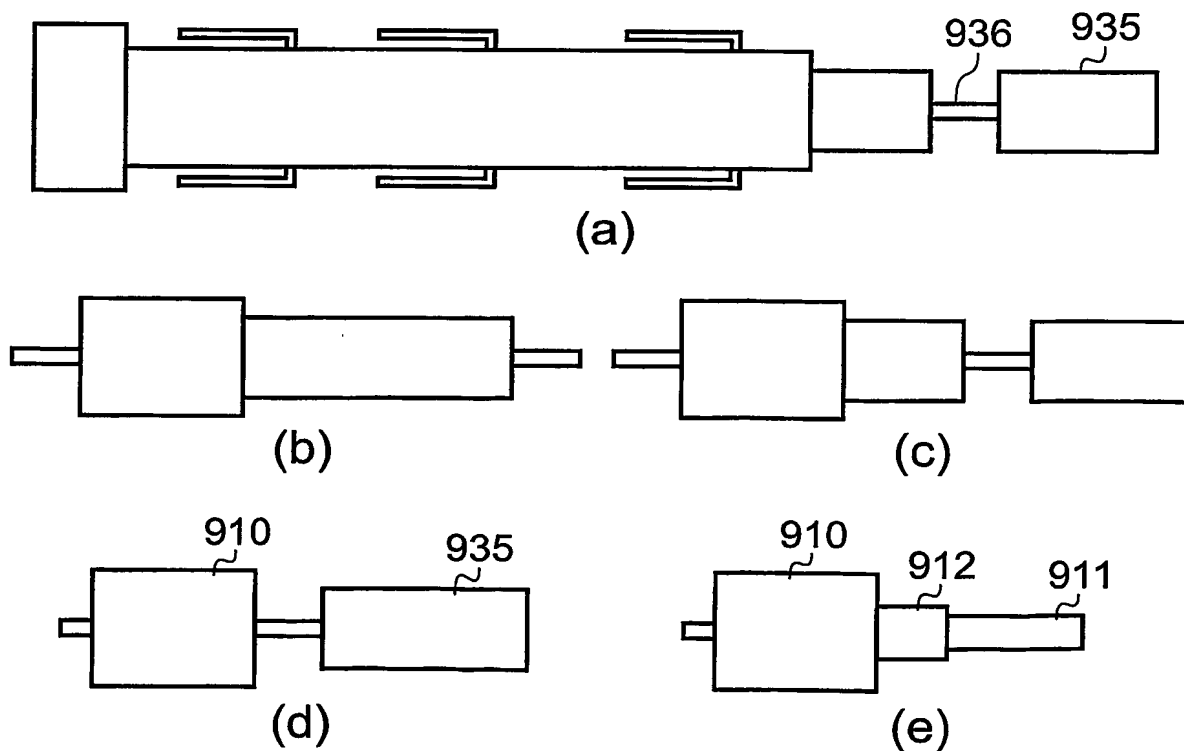


Fig. 11

10/14

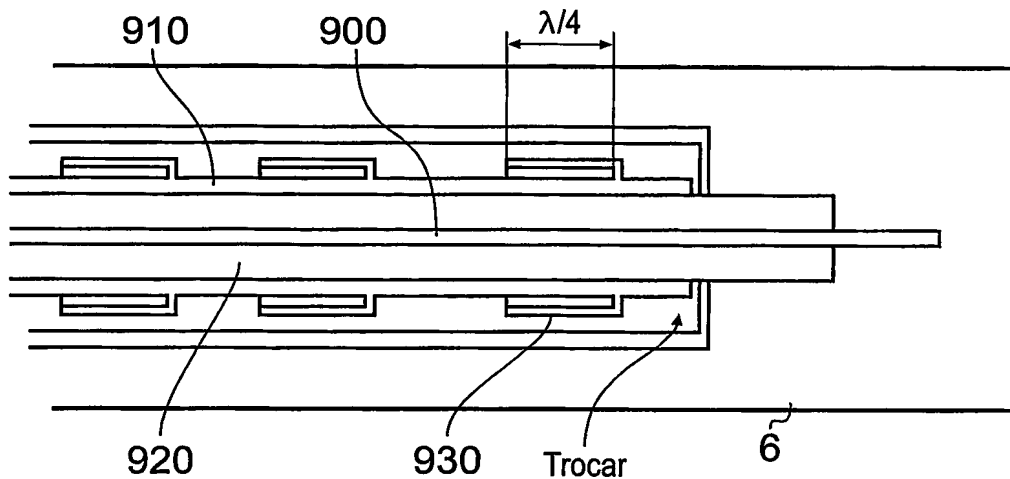


Fig. 12

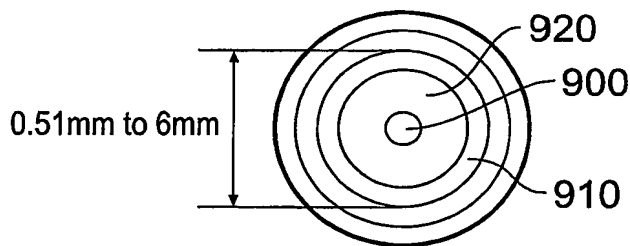


Fig. 13

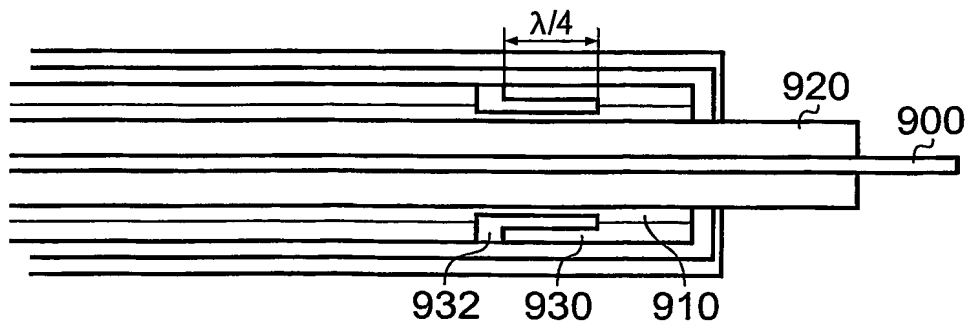


Fig. 14

11/14

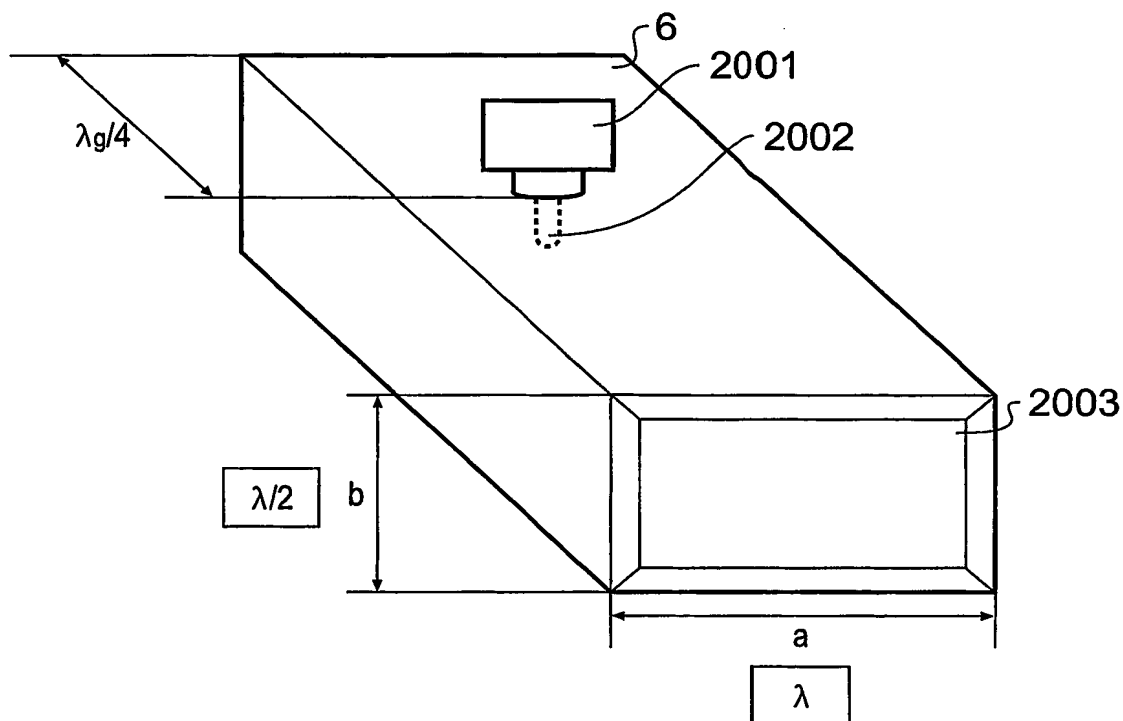


Fig. 15

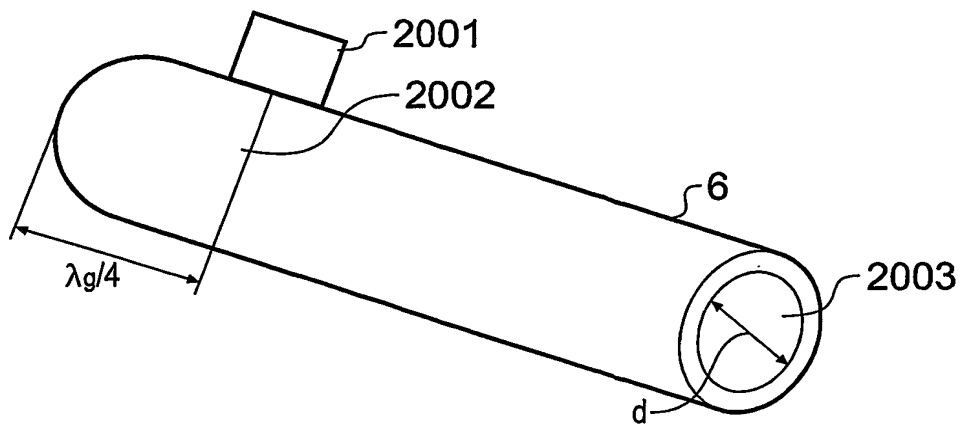
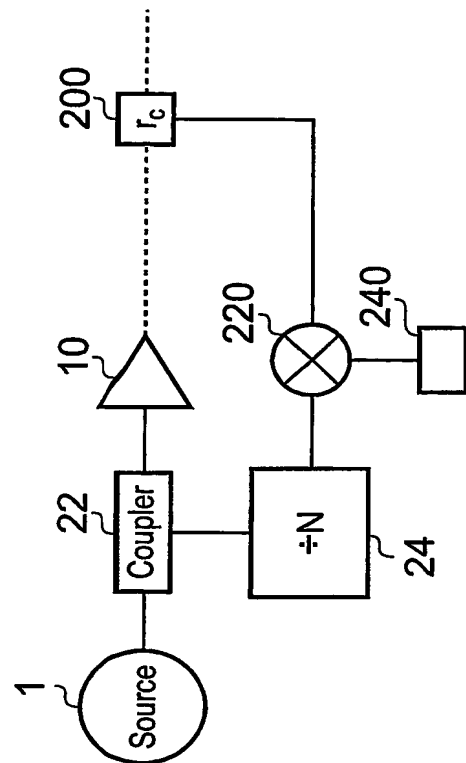
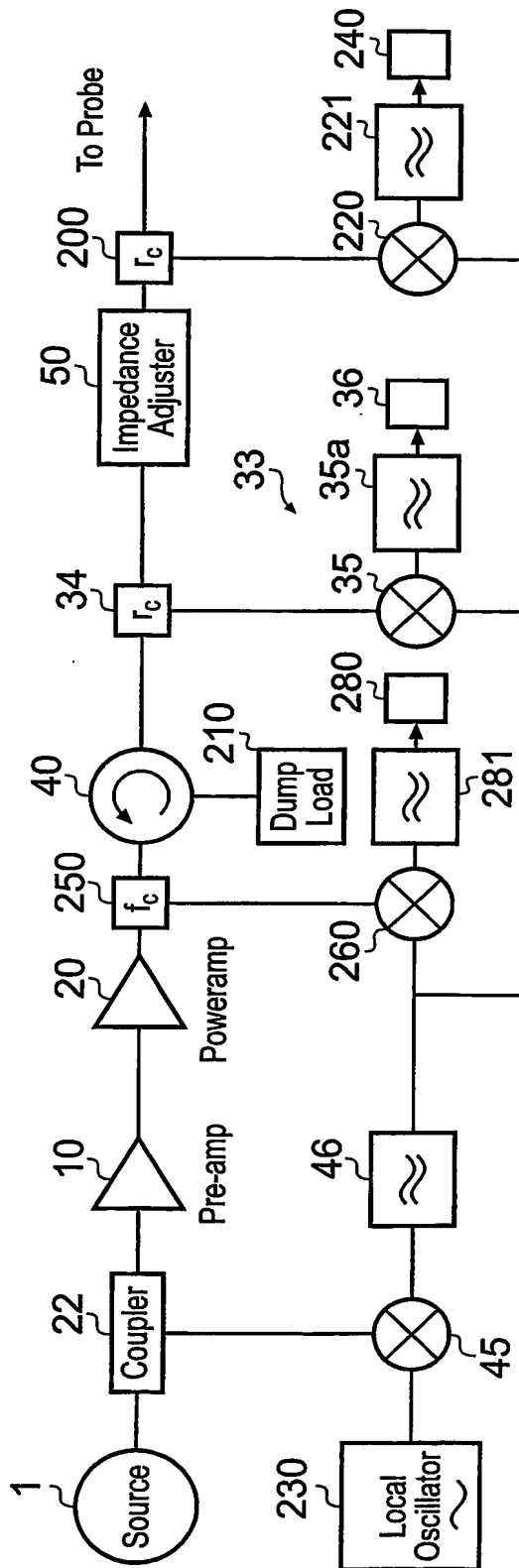


Fig. 22



13/14

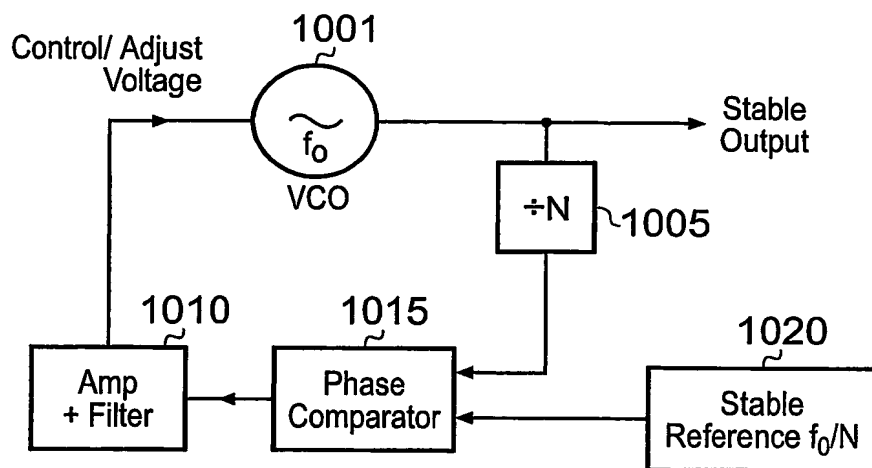


Fig. 19

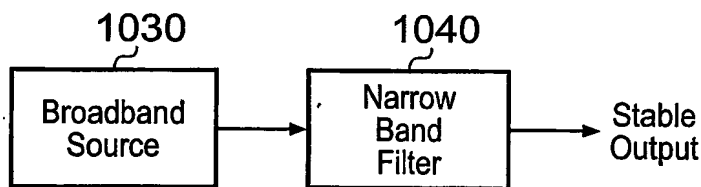


Fig. 20

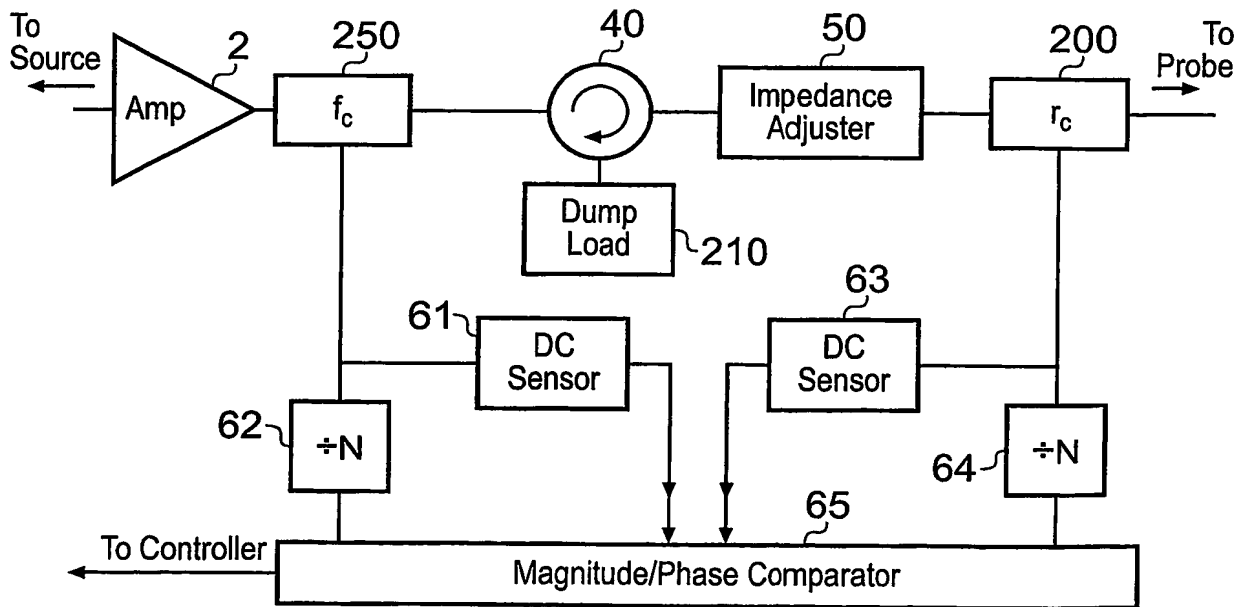


Fig. 18

14/14

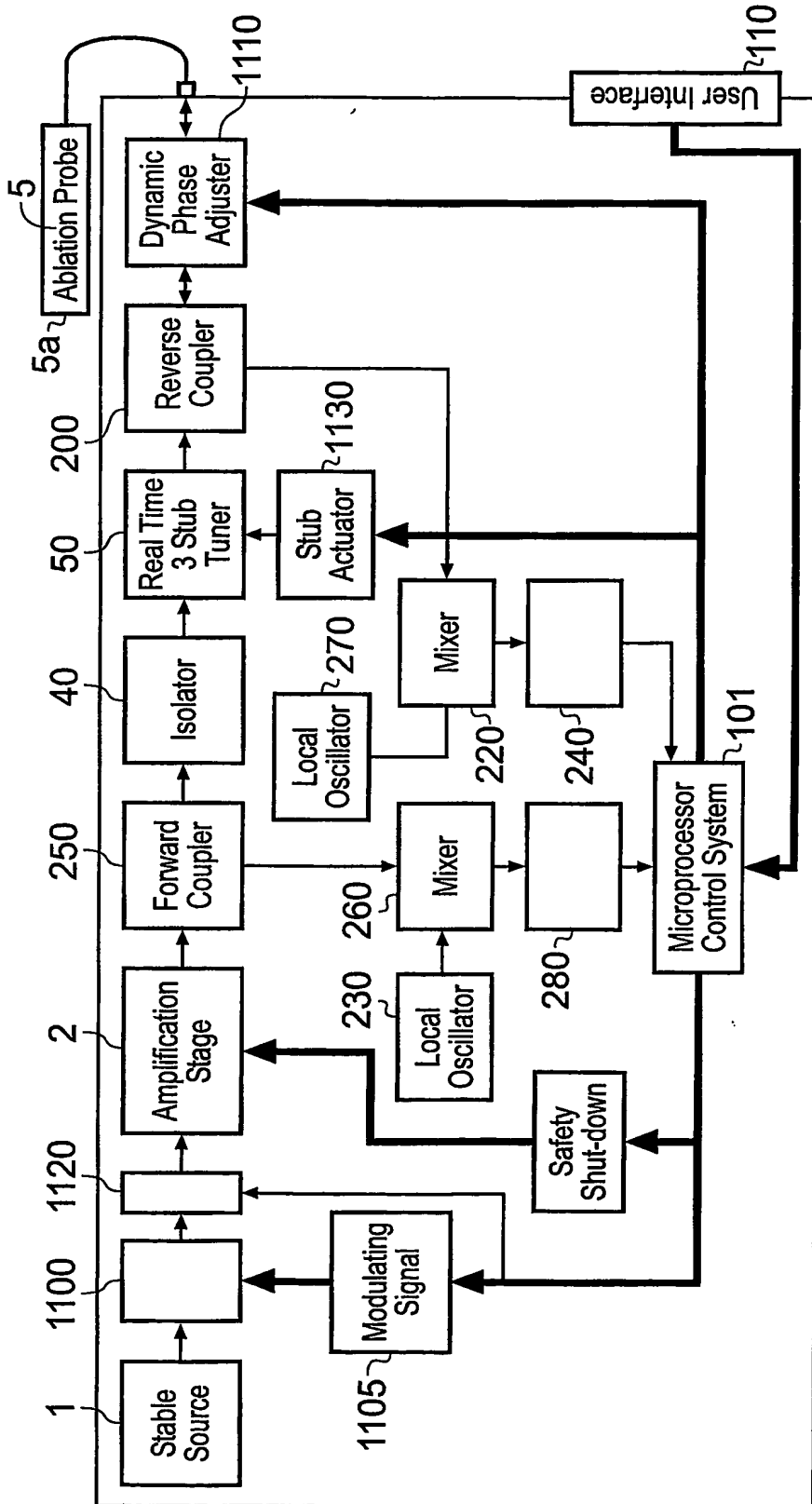


Fig. 21

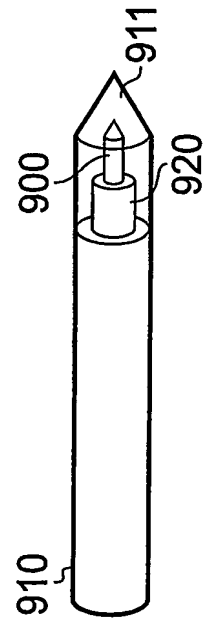


Fig. 23

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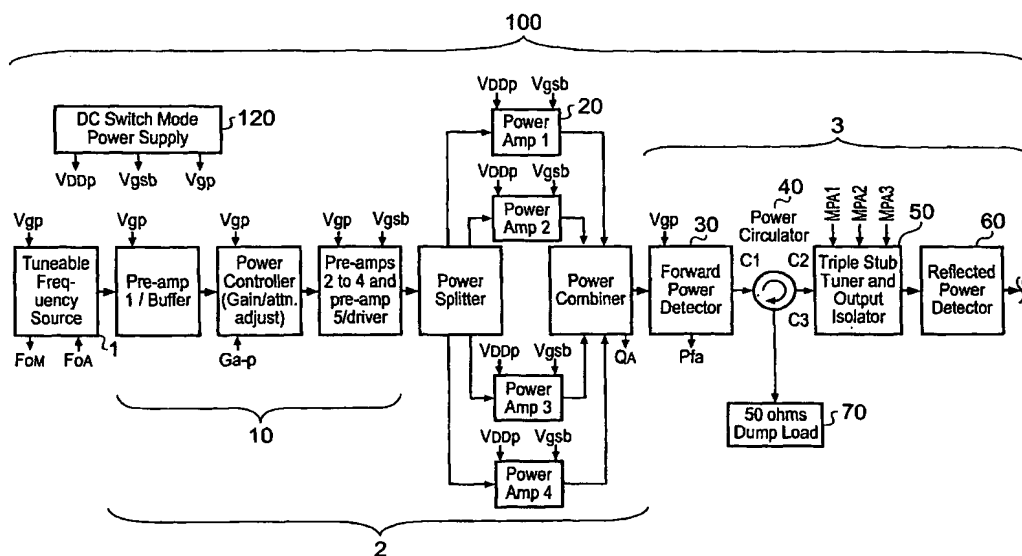
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[Continued on next page]

(54) Title: TISSUE ABLATION APPARATUS AND METHOD OF ABLATING TISSUE



(57) Abstract: An apparatus and method for ablating tissue is disclosed. The apparatus comprises a source of microwave radiation (1), a probe (5) for directing the microwave radiation into tissue, one or more detectors for detecting the power and phase of the microwave radiation and an impedance adjuster (50) for adjusting impedance so as to minimize the amount of microwave radiation which reflected back through the probe. The detector or detectors use a local oscillator (230) to derive the phase information. A modulator for modulating the microwave radiation to a cutting frequency is also disclosed.



— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments*

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INTERNATIONAL SEARCH REPORT

Application No

PCT/GB 03/05166

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 405 346 A (WARNER GLEN G ET AL) 11 April 1995 (1995-04-11) column 3, line 14 -column 12, line 31; figures 2-4,8,9	1-18
X	EP 1 186 274 A (AFX INC) 13 March 2002 (2002-03-13) column 1, line 41 -column 36, line 27; figure 2	1-18
X	US 6 413 255 B1 (STERN ROGER A) 2 July 2002 (2002-07-02)	34,36, 38,39
A	column 3, line 60 -column 30, line 10	37
X	WO 00/53113 A (STERN ROGER ;THERMAGE INC (US)) 14 September 2000 (2000-09-14)	34,36, 38,39
A	page 9, line 8 -page 48, line 14	37
X	US 2002/120261 A1 (MORRIS DAVID L ET AL) 29 August 2002 (2002-08-29)	34,36, 38,39
A	paragraph '0008! - paragraph '0193!; figure 55	37
A	US 6 350 276 B1 (KNOWLTON EDWARD W) 26 February 2002 (2002-02-26)	34,36-39
	column 2, line 20 -column 22, line 32; figures 23-25	
A	WO 97/43971 A (SOMNUS MEDICAL TECH INC ;EDWARDS STUART D (US)) 27 November 1997 (1997-11-27)	34,36-39
	page 4, line 2 -page 31, line 21	

INTERNATIONAL SEARCH REPORT

application No.
PCT/GB 03/05166

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☒ Claims Nos.: 19-26
because they relate to subject matter not required to be searched by this Authority, namely:
Rule 39.1(iv) PCT - Method for treatment of the human or animal body by surgery
2. ☐ Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this International application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☒ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:
1-18, 34, 36-39
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.
- ☒ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. Claims: 1-18

Tunable tissue ablation apparatus

2. Claim : 27

Probe with ceramic tip

3. Claims: 28-33,35,38,39

Coaxial probe and method of making a balun therefor

4. Claims: 34,36-39

Surgical apparatus with modulator

INTERNATIONAL SEARCH REPORT

Information on patent family members

Application No

PCT/GB 03/05166

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
US 5957969	A	28-09-1999	US 5693082 A	02-12-1997
			US 5364392 A	15-11-1994
			US 5405346 A	11-04-1995
			AU 6912794 A	12-12-1994
			EP 0697842 A1	28-02-1996
			WO 9426188 A1	24-11-1994
US 5693082	A	02-12-1997	US 5364392 A	15-11-1994
			US 5405346 A	11-04-1995
			US 5957969 A	28-09-1999
			AU 6912794 A	12-12-1994
			EP 0697842 A1	28-02-1996
			WO 9426188 A1	24-11-1994
US 5364392	A	15-11-1994	AU 6912794 A	12-12-1994
			EP 0697842 A1	28-02-1996
			WO 9426188 A1	24-11-1994
			US 5405346 A	11-04-1995
			US 5693082 A	02-12-1997
			US 5957969 A	28-09-1999
US 5405346	A	11-04-1995	US 5364392 A	15-11-1994
			AU 6912794 A	12-12-1994
			EP 0697842 A1	28-02-1996
			WO 9426188 A1	24-11-1994
			US 5693082 A	02-12-1997
			US 5957969 A	28-09-1999
EP 1186274	A	13-03-2002	EP 1186274 A2	13-03-2002
US 6413255	B1	02-07-2002	US 2002151887 A1	17-10-2002
			US 2002156471 A1	24-10-2002
			US 2003216728 A1	20-11-2003
			US 2004034346 A1	19-02-2004
			US 2003199866 A1	23-10-2003
			US 2004002704 A1	01-01-2004
			US 2004000316 A1	01-01-2004
			US 2003212393 A1	13-11-2003
			US 2004030332 A1	12-02-2004
			US 2004002705 A1	01-01-2004
			US 2003220635 A1	27-11-2003
			AU 3741500 A	28-09-2000
			CA 2364098 A1	14-09-2000
			EP 1158919 A1	05-12-2001
			JP 2002537939 A	12-11-2002
			WO 0053113 A1	14-09-2000
WO 0053113	A	14-09-2000	AU 3741500 A	28-09-2000
			CA 2364098 A1	14-09-2000
			EP 1158919 A1	05-12-2001
			JP 2002537939 A	12-11-2002
			WO 0053113 A1	14-09-2000
			US 2002151887 A1	17-10-2002
			US 2002156471 A1	24-10-2002
			US 2003216728 A1	20-11-2003
			US 2004034346 A1	19-02-2004
			US 2003199866 A1	23-10-2003
			US 2004002704 A1	01-01-2004

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 0053113 A		US 2004000316 A1	01-01-2004
		US 2003212393 A1	13-11-2003
		US 2004030332 A1	12-02-2004
		US 2004002705 A1	01-01-2004
		US 2003220635 A1	27-11-2003
		US 6413255 B1	02-07-2002
US 2002120261 A1	29-08-2002	US 2002120260 A1	29-08-2002
		EP 1370187 A1	17-12-2003
		WO 02067797 A2	06-09-2002
US 6350276 B1	26-02-2002	US 2002062142 A1	23-05-2002
		US 5919219 A	06-07-1999
		US 6430446 B1	06-08-2002
		US 6241753 B1	05-06-2001
		AU 770936 B2	11-03-2004
		AU 5785300 A	31-01-2001
		CA 2376879 A1	04-01-2001
		EP 1196215 A1	17-04-2002
		JP 2003503118 T	28-01-2003
		WO 0100269 A1	04-01-2001
		US 2002049483 A1	25-04-2002
		US 2003216728 A1	20-11-2003
		US 2004034346 A1	19-02-2004
		US 2003199866 A1	23-10-2003
		US 2004002704 A1	01-01-2004
		US 2004000316 A1	01-01-2004
		US 2003212393 A1	13-11-2003
		US 2004030332 A1	12-02-2004
		US 2004002705 A1	01-01-2004
		US 2003220635 A1	27-11-2003
		AU 8903798 A	23-04-1999
		WO 9916502 A1	08-04-1999
		US 6405090 B1	11-06-2002
		AU 3824997 A	25-02-1998
		US 6438424 B1	20-08-2002
		WO 9805286 A1	12-02-1998
		AU 1527397 A	01-08-1997
		AU 5789396 A	21-11-1996
		EP 1407720 A1	14-04-2004
		EP 0957791 A1	24-11-1999
		JP 2001513654 T	04-09-2001
		JP 11504828 T	11-05-1999
		US 6377855 B1	23-04-2002
		US 6381497 B1	30-04-2002
		US 6381498 B1	30-04-2002
		WO 9634568 A1	07-11-1996
		WO 9724992 A1	17-07-1997
		US 6470216 B1	22-10-2002
		US 6461378 B1	08-10-2002
		US 6377854 B1	23-04-2002
WO 9743971 A	27-11-1997	US 5746224 A	05-05-1998
		US 5800429 A	01-09-1998
		US 5827277 A	27-10-1998
		US 5843077 A	01-12-1998
		US 5823197 A	20-10-1998
		AU 3119597 A	26-11-1997

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9743971	A	AU 3204097 A	09-12-1997
		WO 9743971 A2	27-11-1997
		WO 9741789 A1	13-11-1997
		US 2003144659 A1	31-07-2003
		US 2002091381 A1	11-07-2002
		US 6419673 B1	16-07-2002
		US 5743904 A	28-04-1998
		US 6077257 A	20-06-2000
		AU 2191697 A	09-12-1997
		WO 9743970 A1	27-11-1997